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XXIII. *Observations on the fossil Bones presented to the Royal Society by his most Serene Highness the Margrave of Anspach, &c. By the late John Hunter, Esq. F. R. S. Communicated by Everard Home, Esq. F. R. S.*

Read May 8, 1794.

THE bones which are the subject of the present paper, are to be considered more in the light of incrustations than extraneous fossils, since their external surface has only acquired a covering of crystallized earth, and little or no change has taken place in their internal structure.

The earths with which bones are most commonly incrustated are the calcareous, argillaceous, and siliceous, but principally the calcareous; and this happens in two ways; one, the bones being immersed in water in which this earth is suspended; the other, water passing through masses of this earth, which it dissolves, and afterwards deposits upon bones which lie underneath.

Bones which are incrustated seem never to undergo this change in the earth, or under the water, where the soft parts were destroyed; while bones that are fossilized become so in the medium in which they were deposited* at the animal's death. The incrustated bones have been previously exposed to

* Bones that have been buried with the flesh on, acquire a stain which they never lose; and those which have been long immersed in water, receive a considerable tinge.

the open air; this is evidently the case with the bones at present under consideration, those of the rock of Gibraltar, and those found in Dalmatia; and from the account given by the Abbé SPALLANZANI, those of the island of Cerigo are under the same circumstances. They have the characters of exposed bones, and many of them are cracked in a number of places, particularly the cylindrical bones, similar to the effects of long exposure to the sun. This circumstance appears to distinguish them from fossilized bones, and gives us some information respecting their history.

If their numbers had corresponded with what we meet with of recent bones, we might have been led to some opinion of their mode of accumulation; but the quantity exceeds any thing we can form an idea of. In an inquiry into their history three questions naturally arise: did the animals come there and die? or were their bodies brought there, and lay exposed? or were the bones collected from different places? The first of these conjectures appears to me the most natural; but yet I am by no means convinced of its being the true one.

Bones of this description are found in very different situations, which makes their present state more difficultly accounted for. Those in Germany are found in caves. The coast of Dalmatia is said to be almost wholly formed of them, and we know that this is the case with a large portion of the rock of Gibraltar.

If none were found in caves, but in solid masses covered with marl or limestone, it would then give the idea of their having been brought together by some strange cause, as a convulsion in the earth, which threw these materials over them; but this we can hardly form an idea of; or if they had all been

found in caves, we should have imagined these caves were places of retreat for such animals, and had been so for some thousands of years ; and if the bones were those of carnivorous animals and herbivorous, we might have supposed that the carnivorous had brought in many animals of a smaller size which they caught for food ; and this, upon the first view, appears to have been the case with those which are the subject of this paper ; yet when we consider that the bones are principally of carnivorous animals, we are confined to the supposition of their being only places of retreat. If they had been brought together by any convulsion of the earth, they would have been mixed with the surrounding materials of the mountains, which does not appear to be the case ; for although some are found sticking in the sides of the caves incrustated in calcareous matter, this seems to have arisen from their situation in the cave. Such accumulation would have made them coeval with the mountains themselves, which from the recent state of the bones I should very much doubt.

The difference in the state of the bones shows that there was probably a succession of them for a vast series of years ; for if we consider the distance of time between the most perfect having been deposited, which we must suppose were the last, and the present time, we must consider it to be many thousand years ; and if we calculate how long these must still remain to be as far decayed as some others are, it will require many thousand years, a sufficient time for a vast accumulation : from this mode of reasoning, therefore, it would appear that they were not brought here at once in a recent state.

The animal earth, as it is called, at the bottom of these caves, is supposed to be produced by the rotting of the flesh, which is supposing the animals brought there with the flesh on ; but I do

conceive, that if the caves had been stuffed with whole animals, the flesh could not have produced one-tenth part of the earth, and to account for such a quantity as appears to be the produce of animals, I should suppose it the remains of the dung of animals who inhabited the caves, and the contents of the bowels of those they lived upon. This is easily conceived from knowing that there is something similar to it, in a smaller degree, in many caves in this kingdom, which are places of retreat for bats in the winter, and even in the summer, as they only go abroad in the evenings; these caves have their bottoms covered with animal earth, for some feet in depth, in all degrees of decomposition, the lowermost the most pure, and the uppermost but little changed, with all the intermediate degrees; in which caves are formed a vast number of stalactites, which might incrust the bones of those that die there.

The bones in the caves in Germany are so much the object of the curious, that the specimens are dispersed throughout Europe, which prevents a sufficient number coming into the hands of any one person to make him acquainted with the animals to which they belong.

From the history and figures given by ESPER, it appears that there are the bones of several animals; but what is curious, they all appear to have been carnivorous, which we should not have expected. There are teeth in number, kind, and mode of setting, exactly similar to the white bear, others more like those of the lion; but the representations of parts, however well executed, are hardly to be trusted to for the nicer characters, and much less so when the parts are mutilated.

The bones sent by his highness the Margrave of ANSPACH agree with those described and delineated by ESPER as belonging to the white bear; how far they are of the same species

among themselves, I cannot say ; the heads differ in shape from each other ; they are, upon the whole, much longer for their breadth than in any carnivorous animal I know of ; they also differ from the present white bear, which, as far as I have seen, has a common proportional breadth ; it is supposed, indeed, that the heads of the present white bear differ from one another, but the truth of this assertion I have not seen heads enough of that animal to determine.

The heads not only vary in shape, but also in size, for some of them, when compared with the recent white bear, would seem to have belonged to an animal twice its size, while some of the bones correspond in size with those of the white bear, and others are even smaller. *

There are two ossa humeri, rather of a less size than those of the recent white bear ; a first vertebra, rather smaller ; the teeth also vary considerably in size, yet they are all those of the same tribe ; so that the variety among themselves is not less than between them and the recent. In the formation of the head, age makes a considerable difference ; the skull of a young dog is much more rounded than an old one, the ridge leading back to the occiput, terminating in the two lateral ones, hardly exists in a young dog ; and among the present bones there is the back part of such a head, yet it is larger than the head of the largest mastiff ; how far the young white bear may vary from the old, similar to the young dog, I do not know, but it is very probable. Drawings of the different heads and ossa humeri, done in a very

* It is to be understood, that the bones of the white bear that I have, belonged to one that had been a show, and had not grown to the full or natural size ; and I make allowance for this in my assertion, that the heads of those incrustated appear to belong to an animal twice the size of our white bear.

masterly manner by Mr. BATTY, surgeon in Great Marlborough-street, who was so obliging as to take that trouble, are annexed to this account. See Tab. XIX. and XX.

Bones of animals under circumstances so similar, although in different parts of the globe, one would have naturally supposed to consist chiefly of those of one class or order in every place, one principle acting in all places. In Gibraltar they are mostly of the ruminating tribe, of the hare kind, and the bones of birds ; yet there are some of a small dog or fox, and likewise shells. Those in Dalmatia appear to be mostly of the ruminating tribe, yet I saw a part of the os hyoides of a horse ; but those from Germany are mostly carnivorous. From these facts we should be inclined to suppose, that their accumulation did not arise from any instinctive mode of living, as the same mode could not suit both carnivorous and herbivorous animals.

In considering animals respecting their situation upon the globe, there are many which are peculiar to particular climates, and others that are less confined, as herrings, mackerel, and salmon ; others again, which probably move over the whole extent of the sea, as the shark, porpus, and whale tribe ; while many shell-fish must be confined to one spot. If the sea had not shifted its situation more than once, and was to leave the land in a very short time, then we could determine what the climate had formerly been by the extraneous fossils of the stationary animals, for those only would be found mixed with those of passage ; but if the sea moves from one place to another slowly, then the remains of animals of different climates may be mixed, by those of one climate moving over those of another, dying, and being fossilized ; but this I am afraid cannot be made out. By the fossils we may, however, have some idea

how the bones of the land animals fossilized may be disposed with respect to those of the sea.

If the sea should have occupied any space that never had been dry land prior to the sea's being there, the extraneous fossils can only be those of sea animals; but each part will have its particular kind of those that are stationary mixed with a few of the amphibia, and of sea birds, in those parts that were the skirts of the sea. I shall suppose that when the sea left this place it moved over land where both vegetables and land animals had existed, the bones of which will be fossilized, as also those of the sea animals; and if the sea continued long here, which there is reason to believe, then those mixed extraneous fossils will be covered with those of sea animals. Now if the sea should again move and abandon this situation, then we should find the land and sea fossils above mentioned disposed in this order; and as we begin to discover extraneous fossils in a contrary direction to their formation, we shall first find a stratum of those of animals peculiar to the sea, which were the last formed, and under it one of vegetables and land animals, which were there before they were covered by the sea, and among them those of the sea, and under this the common earth. Those peculiar to the sea will be in depth in proportion to the time of the sea's residence and other circumstances, as currents, tides, &c.

From a succession of such shiftings of the situation of the sea we may have a stratum of marine extraneous fossils, one of earth, mixed probably with vegetables and bones of land animals, a stratum of terrestrial extraneous fossils, then one of marine productions; but from the sea carrying its inhabitants along with it, wherever there are those of land animals there

will also be a mixture of marine ones; and from the sea commonly remaining thousands of years in nearly the same situation, we have marine fossils unmixed with any others.

All operations respecting the growth or decomposition of animal and vegetable substances go on more readily on the surface of the earth than in it; the air is most probably the great agent in decomposition and combination, and also a certain degree of heat. Thus the deeper we go into the earth, we find the fewer changes going on; and there is probably a certain depth where no change of any kind can possibly take place. The operation of vegetation will not go on at a certain depth, but at this very depth a decomposition can take place, for the seed dies, and in time decays; but at a still greater depth, the seed retains its life for ages, and when brought near enough to the surface for vegetation, it grows. Something similar to this takes place with respect to extraneous fossils; for although a piece of wood or bone is dead, when so situated as to be fossilized, yet they are sound and free from decomposition, and the depth, joined with the matter in which they are often found, as stone, clay, &c. preserves them from putrefaction, and their dissolution requires thousands of years to complete it; probably they may be under the same circumstances as in a vacuum; the heat in such situations is uniform, probably in common about 52° or 53° , and in the colder regions they are still longer preserved.

I believe it is generally understood that in extraneous fossils the animal part is destroyed; but I find that this is not the case in any I have met with.

Shells, and bones of fish, most probably have the least in quantity, having been longest in that state, otherwise they

should have the most ; for the harder and more compact the earth, the better is the animal part preserved ; which is an argument in proof of their having been the longest in a fossil state. From experiment and observation, the animal part is not allowed to putrefy, it appears only to be dissolved into a kind of mucus, and can be discovered by dissolving the earth in an acid ; when a shell is treated in this way, the animal substance is not fibrous or laminated, as in the recent shell, but without tenacity, and can be washed off like wet dust ; in some, however, it has a slight appearance of flakes.

In the shark's tooth, or *glossopetra*, the enamel is composed of animal substance and calcareous earth, and is nearly in the same quantity as in the recent ; but the central part of the tooth has its animal substance in the state of mucus interspersed in the calcareous matter.

In the fossil bones of sea animals, as the *vertebræ* of the whale, the animal part is in large quantity, and in two states ; the one having some tenacity, but the other like wet dust : but in some of the harder bones it is more firm.

In the fossil bones of land animals, and those which inhabit the waters, as the sea-horse, otter, crocodile, and turtle, the animal part is in considerable quantity. In the stags horns dug up in Great Britain and Ireland, when the earth is dissolved, the animal part is in considerable quantity, and very firm. The same observations apply to the fossil bones of the elephant found in England, Siberia, and other parts of the globe ; also those of the ox kind ; but more particularly to their teeth, especially those from the lakes in America, in which the animal part has suffered very little ; the inhabitants find little difference in the ivory of such tusks from the

recent, but its having a yellow stain ; the cold may probably assist in their preservation.

The state of preservation will vary according to the substance in which they have been preserved ; in peat and clay I think the most ; however, there appears in general a species of dissolution ; for the animal substance, although tolerably firm, in a heat a little above 100° becomes a thickish mucus, like dissolved gum, while a portion from the external surface is reduced to the state of wet dust.

In incrustated bones, the quantity of animal substance is very different in different bones. In those from Gibraltar there is very little ; it in part retains its tenacity, and is transparent, but the superficial part dissolves into mucus.

Those from Dalmatia give similar results when examined in this way.

Those from Germany, especially the harder bones and teeth, seem to contain all the animal substance natural to them, they differ however among themselves in this respect.

The bones of land animals have their calcareous earth united with the phosphoric acid instead of the aerial, and I believe, retain it when fossilized, nearly in proportion to the quantity of animal matter they contain.

The mode by which I judge of this, is by the quantity of effervescence ; when fossil bones are put into the muriatic acid it is not nearly so great as when a shell is put into it, but it is more in some, although not in all, than when a recent bone is treated in this way, and this I think diminishes in proportion to the quantity of animal substance they retain ; as a proof of this, those fossil bones which contain a small portion of animal matter, produce in an acid the greatest effervescence when the

Fig. 1.

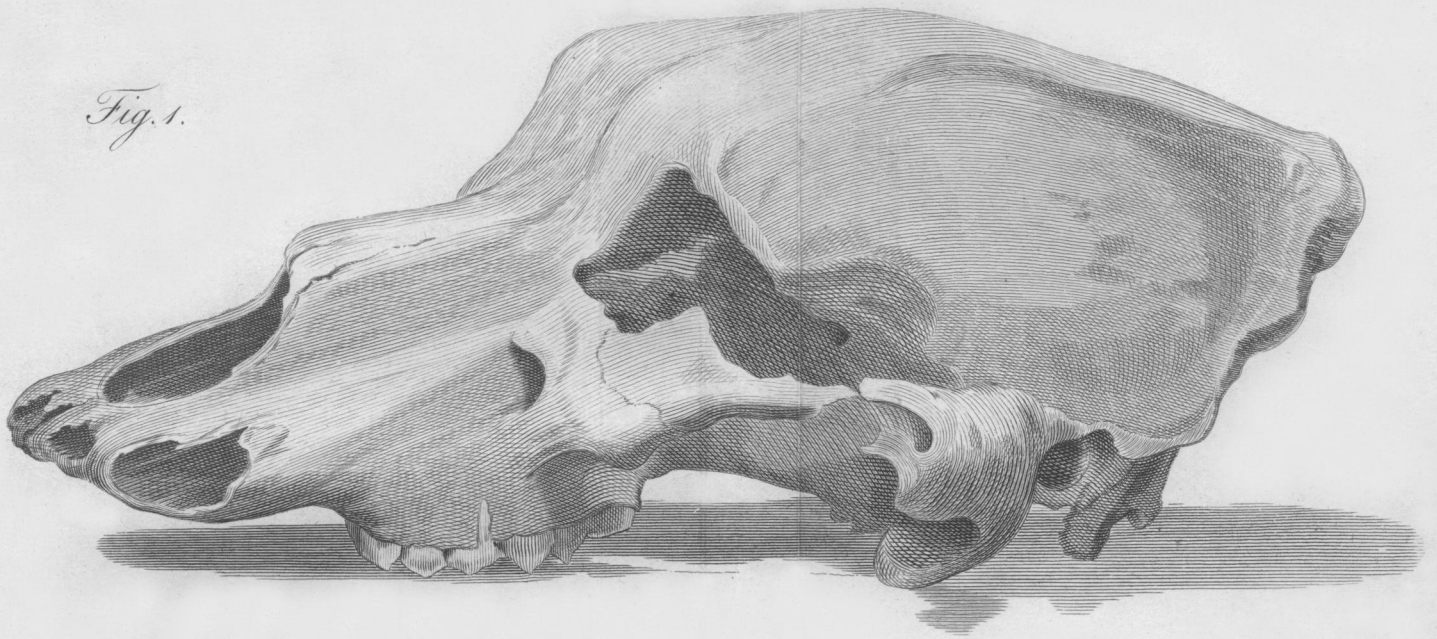


Fig. 2.

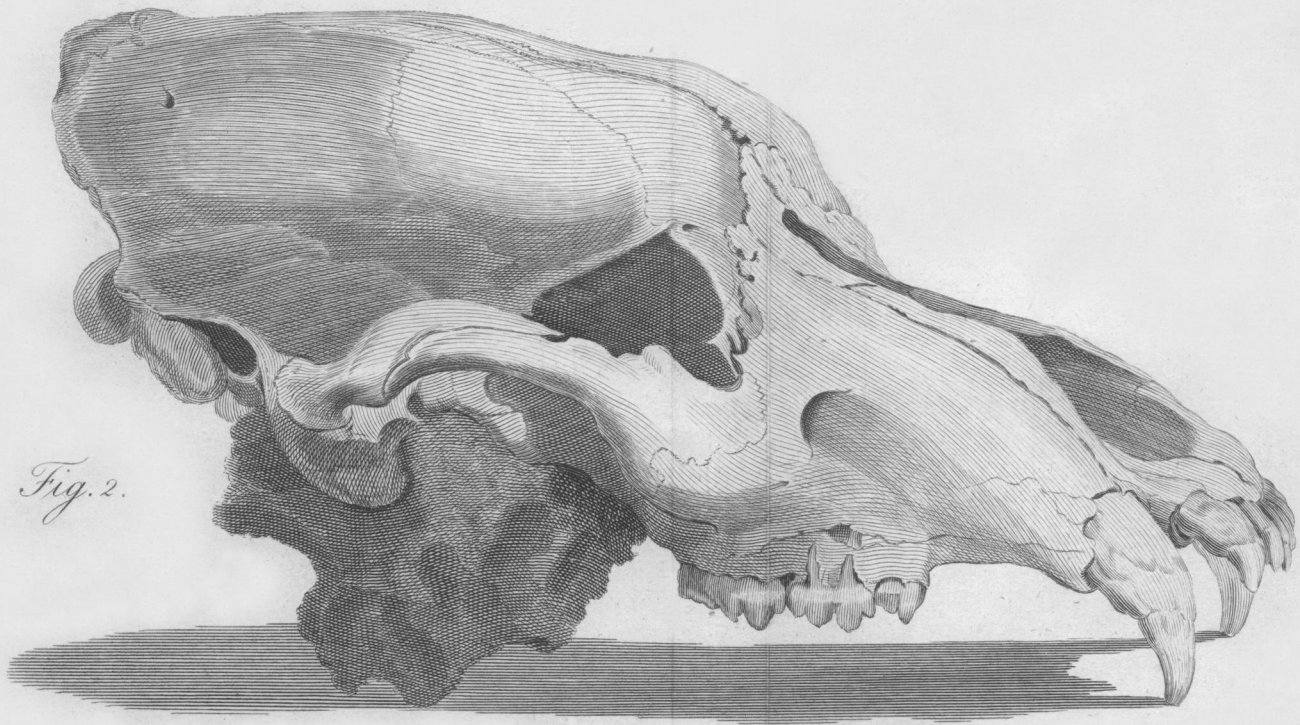


Fig. 1.

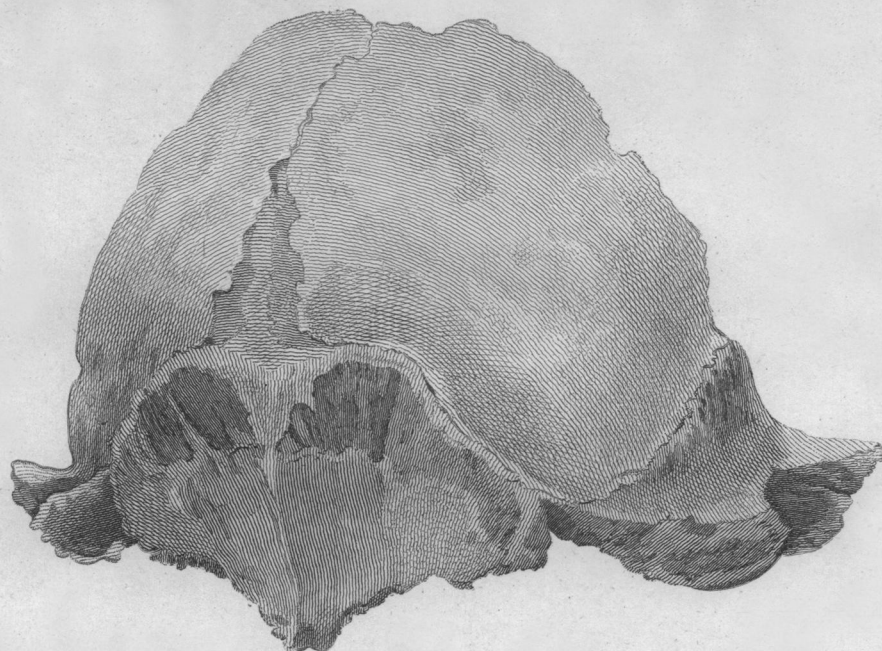


Fig. 2.



surface is acted on, and very little when the centre is affected by it; however, this may be accounted for by the parts which have lost their phosphoric acid, and acquired the aerial, being easiest of solution in the marine acid, and therefore dissolved first, and the aerial acid let loose.

In some bones of the whale the effervescence is very great; in the Dalmatia and Gibraltar bones it is less; and in those the subject of the present paper it is very little, since they contain by much the largest proportion of animal substance.

EXPLANATION OF THE PLATES.

Tab. XIX.

Fig. 1. One of the incrusted skulls sent over by the Margrave of ANSPACH, which is much larger than that of the common white bear, longer for its breadth, and having a greater hollow between the anterior part of the skull and the bones of the face.

Fig. 2. Another skull, which differs in many respects from fig. 1. and nearly in the same degree that the first does from the skull of the recent white bear.

Tab. XX.

Fig. 1. A portion of a skull; to what animal it belongs is not exactly ascertained, unless it be the growing state of the bones in one of the varieties of the white bear species, but it is materially different from the full grown skulls expressed in Tab. XIX. It is rather too large in proportion to the others.

Fig. 2. Two of the incrusted ossa humeri, to shew that these bones vary very much among themselves, these two being in many respects dissimilar.